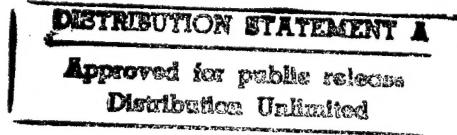


September 1998

# NATIONAL AIRSPACE SYSTEM

## FAA Has Implemented Some Free Flight Initiatives, but Challenges Remain



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**Resources, Community, and  
Economic Development Division**

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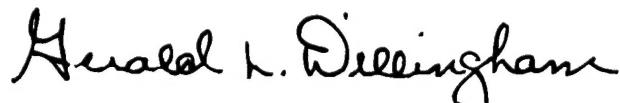
September 28, 1998

The Honorable John McCain  
Chairman  
The Honorable Ernest F. Hollings  
Ranking Minority Member  
Committee on Commerce, Science, and  
Transportation  
United States Senate

The Honorable Slade Gorton  
Chairman  
The Honorable Wendell H. Ford  
Ranking Minority Member  
Subcommittee on Aviation  
Committee on Commerce, Science, and  
Transportation  
United States Senate

In response to your request, this report discusses the results of our review of (1) the status of the Federal Aviation Administration's (FAA) efforts to implement free flight, including a planned operational demonstration formerly known as Flight 2000 and now called the Free Flight Operational Enhancement Program, and (2) the views of the aviation community and FAA on the challenges that must be met to implement free flight in a cost-effective manner.

We are providing copies of this report to interested congressional committees and subcommittees, the Secretary of Transportation, the Administrator of the Federal Aviation Administration, and other interested parties. Copies will also be made available to others upon request. Please call me at (202) 512-3650 if you have any questions about the report. Major contributors to this report are listed in appendix V.



Gerald L. Dillingham, Ph.D.  
Associate Director, Transportation Issues

# Executive Summary

## Purpose

The predicted growth in air traffic and the aging of air traffic control equipment led the Federal Aviation Administration (FAA) to undertake a multibillion-dollar modernization effort in 1981 to improve the safety, capacity, and efficiency of the nation's air traffic control system. Since that time, this program has experienced substantial cost overruns, lengthy schedule delays, and significant performance shortfalls. To get the modernization effort back on track and thereby address the limitations of the present system and satisfy users' growing demands, FAA—in consultation with the aviation community—is developing a phased approach to modernization, including a new way of managing air traffic known as "free flight." Under the modernization program, FAA plans to introduce a host of new technologies and procedures that will enable free flight—allowing the agency to move gradually from its present use of highly structured rules and procedures for air traffic operations to a more flexible system in which decisions for conducting flight operations will be based increasingly on collaboration between FAA and users. For example, these technologies and associated procedures will give pilots and controllers more precise information about the location of aircraft and allow them to exchange information more efficiently. With more precise and efficiently exchanged information, pilots will have more flexibility to change their route, speed, and altitude (under certain conditions) with fewer restrictions, thus saving users time and money and allowing FAA to improve the air traffic control system's safety and use airspace and airport resources more efficiently.

Because FAA is at a critical juncture in its plans to implement this new system of air traffic management, the Senate Committee on Commerce, Science, and Transportation and its Subcommittee on Aviation asked GAO to monitor the progress of free flight initiatives and provide them with a series of reports. This first report discusses (1) the status of FAA's efforts to implement free flight, including a planned operational demonstration known as Flight 2000,<sup>1</sup> and (2) the views of the aviation community and FAA on the challenges that must be met to implement free flight cost-effectively.

## Background

FAA's mission is to promote the safe, orderly, and expeditious flow of air traffic in the U.S. airspace system, commonly referred to as the National Airspace System (NAS). To accomplish its mission, FAA provides air traffic

<sup>1</sup>FAA officials working with the aviation community reached broad consensus on a general roadmap for restructuring the Flight 2000 program—including a recommendation that it be renamed the "Free Flight Operational Enhancement Program"—and presented this roadmap to FAA for formal approval in Sept. 1998.

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services 24 hours a day, 365 days a year. The air traffic control system, which is the principal component of the NAS, comprises a vast network of radars; automated data processing, navigation, and communications equipment; and air traffic control facilities. Through the air traffic control system, FAA, among other things, controls takeoffs and landings and manages the flow of traffic between airports. Other components of the NAS include airports or landing areas; aeronautical charts, information, and services; rules, regulations, and procedures; technical information; and personnel and material.

Over the past 17 years, FAA has had an ongoing program to modernize the air traffic control system. Under this program, FAA is upgrading and replacing equipment and facilities and developing new technologies to help improve the safety, efficiency, and capacity of the system. However, this program has substantially exceeded its budget, encountered lengthy delays, and fallen short in its performance. As a result, the aviation community's confidence in FAA's ability to manage the modernization program has been weakened. While many of FAA's efforts under the modernization program, such as replacing controllers' workstations and supporting equipment, are not a part of the free flight initiatives, these efforts will provide the infrastructure that is critical for its implementation. To address the shortcomings in its modernization program and develop consensus on and commitment to the agency's future approach to both modernization and free flight, FAA has been working with the aviation system's users and their major trade organizations, representatives of air traffic control personnel, equipment manufacturers, the Department of Defense (DOD), and others (collectively referred to as stakeholders).

Free flight is a new system of air traffic management that will provide controllers and pilots with new technologies and procedures that will allow them to increase the safety, capacity, and efficiency of air traffic operations throughout the NAS. The implementation of free flight is expected to affect a wide range of users—from part-time pilots to major airlines—and allow many of them to take advantage of increased operating flexibilities. Despite the availability of such flexibilities to pilots, controllers will retain the ultimate decision-making authority for air traffic operations.

## Results in Brief

Since 1994, FAA officials and stakeholders, under the leadership of RTCA, have been collaborating to implement free flight.<sup>2</sup> These early efforts led to a definition of free flight, a set of recommendations—most of which contain implementing initiatives—and an action plan to gradually move toward a more flexible operating system. While working to implement the recommendations, FAA and stakeholders agreed on the need to focus their efforts on deploying technologies that will provide early benefits to users. In early 1998, FAA and stakeholders developed a strategy that calls for the phased implementation of free flight, beginning with Free Flight Phase 1. Under this first phase, FAA and stakeholders have agreed upon the core technologies that are expected to provide these early benefits, as well as the locations where they will be deployed. However, until recently, FAA and many stakeholders have not agreed on how best to conduct a limited operational demonstration of free-flight-related technologies and procedures—known as the Flight 2000 program.<sup>3</sup> FAA is currently prohibited from spending any fiscal year 1998 funds on the Flight 2000 demonstration itself. Congressional conferees for the Department of Transportation's fiscal year 1998 appropriations act stated that additional financial and technical planning were needed before the demonstration program would be funded. Stakeholders concurred that FAA had yet to develop a detailed plan for conducting this demonstration. While they generally agreed with the need for such a demonstration, they have questioned whether the lessons learned from FAA's recommended demonstration, to be conducted primarily in Alaska and Hawaii, would be transferable to operations in the continental United States, where free flight operations will ultimately focus. To address the concerns of stakeholders, FAA has been working with them—under the leadership of RTCA—to restructure the Flight 2000 demonstration. FAA and stakeholders agreed on a general roadmap for the demonstration, including a recommendation that the demonstration be renamed the “Free Flight Operational Enhancement Program,” and presented it to FAA for approval in September 1998.

Despite these efforts, FAA and stakeholders have identified numerous challenges that will need to be met if free flight—including Free Flight

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<sup>2</sup>RTCA serves in an advisory capacity to FAA, making recommendations that are subject to approval by FAA. It was organized as the Radio Technical Commission for Aeronautics in 1935 to provide a forum where industry and government representatives could discuss aviation issues and develop consensus-based recommendations. In Nov. 1991, it reorganized and shortened its name to RTCA.

<sup>3</sup>Flight 2000 (now the Free Flight Operational Enhancement Program) is intended as a risk-mitigation demonstration of communication, navigation, and surveillance technologies planned for use under future phases of free flight.

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Phase 1 and Flight 2000 (now the Free Flight Operational Enhancement Program)—is to be implemented cost-effectively:

- Stakeholders told GAO that FAA will need to provide effective leadership and management of the modernization efforts both within and outside the agency.
- Stakeholders cited the need for FAA—in collaboration with them—to further develop its plans for implementing free flight, including establishing clear goals for what it intends to achieve and developing measures for tracking the progress of modernization and free flight.
- FAA and stakeholders agreed on the need to address outstanding issues related to technology development and deployment, such as improving the agency's process for determining that new equipment is safe for its intended use and addressing the impact of modernization on human operators, including controllers, maintenance staff, and pilots.
- FAA and stakeholders also identified a range of other challenges that will need the agency's attention, including coordinating FAA's modernization and free flight efforts with those of the international community and integrating the various technologies that will be used under free flight operations with one another as well as into the air traffic control system.

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## Principal Findings

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### Status of Free Flight Implementation Efforts

In 1995, FAA and stakeholders defined free flight and outlined 44 recommendations—many of which have multiple initiatives—for consideration in implementing free flight.<sup>4</sup> In 1996, they developed an action plan with time frames to guide the implementation of these recommendations. Since that time, they have fully implemented 1 of 35 recommendations scheduled for completion by the end of 1997 and have made substantial progress toward completing initiatives under many of these and the remaining recommendations.<sup>5</sup> Under the fully implemented recommendation, FAA has incorporated airline schedule updates (e.g., airline delays and cancellations) into its Traffic Flow Management system to allow the agency to work more effectively with the airlines to reduce unnecessary operating restrictions and delays. In addition, under a

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<sup>4</sup>The 44 recommendations were developed by FAA and stakeholders under RTCA Free Flight Task Force 3. This task force was conducted under the leadership of RTCA, a nonprofit organization that serves as an advisor to FAA.

<sup>5</sup>The remaining nine recommendations are scheduled to be implemented between 1998 and 2001/beyond.

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recommendation to extend the benefits of data exchange, FAA has deployed digital displays of departure information in lieu of voice messages for pilots' use at 57 sites, as planned, and is currently working to expand the digital exchange of information about weather, airport, and facility conditions. Digital communications provide an advantage over voice communications by helping to relieve congested voice frequencies and reduce the number of operational errors that are caused directly or indirectly by miscommunication. Under another recommendation, FAA and stakeholders are working under the leadership of RTCA to improve the process that the agency uses to ensure that new technologies are safe for their intended use. Furthermore, as part of another recommendation, FAA has deployed technology—on a limited basis—to improve the sequencing of airplanes as they enter, depart, and operate within terminal airspace.

In addition to implementing the recommendations and their initiatives, FAA began to allow users to choose routes and use procedures (under certain conditions) that could save them time and money through two ongoing programs—the National Route Program and the Future Air Navigation System. In 1990, FAA launched the National Route Program to give users the flexibility to select and fly more direct routes. FAA estimates that the aviation industry saves over \$40 million annually through participation in this program. Under the Future Air Navigation System program, which is conducted primarily over the oceans, new technology is used to improve the efficiency of communications between pilots and controllers. This technology, in combination with new procedures, is expected to provide them with more precise information on the location of aircraft so that distances between aircraft can be safely reduced—enabling users to save time and money. However, stakeholders told GAO that because FAA has not deployed the promised hardware and software infrastructure to support the use of these new technologies, the benefits to users have been marginal.

FAA's collaborative efforts with the aviation community to develop plans for implementing free flight have led to a general consensus on an incremental approach—beginning with Free Flight Phase 1—that would cost less for FAA and extend early benefits to users. This first phase is expected to provide these early benefits through the limited deployment of technologies that are intended to enhance the system's safety, capacity, and efficiency. For example, these technologies are expected to provide controllers with better information to detect and resolve potential conflicts between aircraft and to sequence traffic more efficiently. With such information, controllers will be able to give pilots increased

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flexibility to fly more optimal routes but will retain the ultimate authority for decision-making. FAA expects to implement Free Flight Phase 1 by 2002 and is currently developing a plan that will provide more details on implementing the program.

FAA and many stakeholders have disagreed on how best to implement Flight 2000—a limited operational demonstration of new technologies and procedures that was to be used under free flight to improve communication, navigation, and surveillance capabilities. Initially, FAA announced this initiative without consulting users, and disagreements persisted until recently, despite FAA's ongoing efforts to resolve them collaboratively. FAA believed that the Flight 2000 demonstration, as planned primarily for Alaska and Hawaii, was a means to mitigate the risks associated with implementing free flight. While many stakeholders agree with the need to mitigate risks, they have had strong reservations about conducting this demonstration in these remote locations, believing that the lessons learned there will not transfer well to operations in the continental United States. To address these concerns, FAA and stakeholders—working under the leadership of RTCA—developed a roadmap for restructuring Flight 2000 and presented it to FAA in September 1998. Among other things, this roadmap recommended that (1) the program be conducted in the Ohio Valley and Alaska, (2) nine major operational capabilities be implemented, and (3) the demonstration be renamed the "Free Flight Operational Enhancement Program." In developing this roadmap, both FAA and stakeholders emphasized the critical role of safety in achieving operational efficiencies, and many components of the program are designed to enhance safety. FAA is currently considering RTCA's roadmap. While FAA had planned to begin the Flight 2000 demonstration by 2000, time frames for the new demonstration are uncertain because issues such as funding and the need for additional planning have not been resolved.

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**Challenges to  
Implementing Free Flight  
Successfully**

FAA and stakeholders generally agree on the phased approach to implementing free flight but have identified several challenges that must be addressed if free flight is to be implemented cost-effectively.

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**Effective Management Is the Key to Successful Implementation**

Some stakeholders and FAA officials believe that strong FAA leadership is needed both within and outside the agency to successfully implement free flight. In particular, they maintain that FAA needs to encourage more effective communication and coordination among its various program offices responsible for modernization. According to some stakeholders and FAA officials, despite the agency's move to use integrated cross-program teams to improve coordination, this effort has fallen short because some participants are more beholden to their individual program offices than they are to the goals of the team. FAA has begun to develop incentives to encourage staff to work more cooperatively. As for FAA's leadership within the aviation community, some stakeholders cited the need for FAA to make and stick to its decisions so that they can move forward with their plans for free flight. While stakeholders recognize that FAA must balance competing priorities, they find it frustrating when the agency announces a course of action and then either drops the effort or moves in a different direction. Some stakeholders told GAO that this indecision has eroded their confidence in FAA's ability to lead modernization efforts, including free flight. Effective leadership will also be critical to successfully implement the planned evolutionary approach to developing and deploying technology and to demonstrate that FAA can effectively manage its air traffic control modernization programs and deliver promised capabilities.

**Clear Goals and Measures and Sufficiently Detailed Plans Are Needed**

To move safely and efficiently from the present system to free flight, stakeholders said that FAA needs to develop specific goals for what it intends to achieve and a system for measuring its progress. For example, one stakeholder cautioned that if FAA does not fully consider what the system needs to look like 10 to 20 years from now, it runs the risk of investing in technologies that may not address the system's future needs. In addition, some stakeholders and FAA officials agree on the need to develop baseline data for use in tracking their progress in improving the system's safety, capacity, and efficiency. As a next step, stakeholders maintain that the transition to free flight will require FAA to develop detailed plans for the various activities under free flight, including Free Flight Phase 1, Flight 2000 (now the Free Flight Operational Enhancement Program), and various follow-on efforts. Stakeholders told GAO that these plans need to include cost/benefit analyses to provide them with assurances that their investments in free flight technologies will result in benefits to quickly offset expenses. They also said that new procedures are critical to allowing them to fully exploit these benefits and expressed concern that such procedures will not be developed and implemented in a timely fashion.

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**Issues Related to Technology Development and Deployment Remain to Be Resolved**

FAA and stakeholders recognize that certain issues related to the development and deployment of free flight technology need to be resolved. Chief among these issues is the need for FAA to streamline its process for determining that new equipment is safe for its intended use. However, several stakeholders cautioned that FAA will need to take care to ensure that changes to the process do not inadvertently compromise safety. FAA and the aviation community are currently working together to identify possible solutions. Many stakeholders also noted that successfully implementing free flight is inextricably linked to identifying and addressing issues associated with human factors. These issues include developing a reasonably paced training schedule to help ensure that pilots, controllers, and maintenance staff are not overburdened by too many changes at one time, as well as identifying risks associated with changes in technologies and procedures and the potential effects of these changes on human operations in a free flight environment.

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**Other Outstanding Issues May Limit the Effectiveness of Free Flight Implementation**

FAA and stakeholders identified other challenges that must be met for free flight to be successfully implemented. For example, airlines that operate internationally and DOD believe that FAA needs to work diligently to ensure that, to the extent possible, users do not have to purchase multiple sets of equipment to meet different operating requirements in various parts of the world. While FAA is currently working with its international counterparts on various issues related to modernization—including issues related to free flight—some stakeholders question the sufficiency of the agency's efforts to coordinate technology selection decisions that will allow users to operate worldwide.

Some stakeholders and FAA officials cited the need for FAA to ensure that, to the extent possible, technologies will work together to maximize potential benefits. For example, FAA has new technologies that are expected to improve the efficiency of operations at high altitudes, close to the terminal, and on the ground. Because some of these technologies have not been designed to work together, some stakeholders and FAA officials contend that their potential benefits—e.g., allowing distances between aircraft to be safely reduced, when practical, throughout a flight's operation—will not be maximized unless the technologies are integrated. The agency recognizes that it does not have the internal expertise or experience to integrate the hardware and software that will be on board participating aircraft as part of the Flight 2000 demonstration (now the Free Flight Operational Enhancement Program) and plans to hire an integration contractor to do this work. Finally, stakeholders also stressed

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that the benefits of free flight depend on having adequate airport surface capacity (such as runways and gates) and question whether FAA is paying enough attention to the system's lack of such capacity. They noted that if users get to their destination more quickly, only to be delayed by limited airport capacity, they will lose some or all of the expected benefits.

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## **Agency Comments**

GAO provided copies of a draft of this report to FAA for its review and comment. GAO met with FAA officials, including the Director, Program Office, Free Flight Phase 1, and the Acting Program Directors for Flight 2000 and Architecture and Systems Engineering, who generally agreed with the contents of the report and provided clarifying comments that have been incorporated as appropriate.



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## Abbreviations

ADS	Automatic Dependent Surveillance
ADS-B	Automatic Dependent Surveillance-Broadcast
ARINC	Aeronautical Radio Incorporated
ARTCC	Air Route Traffic Control Center
ATC	air traffic control
ATIS	Automatic Terminal Information Service
ATM	Air Traffic Management
CDM	Collaborative Decision Making
CPDLC	Controller Pilot Data Link Communications
CTAS	Center TRACON Automation System
DOD	Department of Defense
DSR	Display System Replacement
DSS	decision support system
FAA	Federal Aviation Administration
FANS	Future Air Navigation System
FAST	Final Approach Spacing Tool
FIS	Flight Information Service
GAO	General Accounting Office
GPS	Global Positioning System
HF	High Frequency
LAAS	Local Area Augmentation System
MDCRS	Meteorological Data Collection and Reporting System
MIT	Massachusetts Institute of Technology
NAS	National Airspace System
NRP	National Route Program
PDC	Pre-Departure Clearance
pFAST	passive Final Approach Spacing Tool
R&D	research and development
RNAV	Random Navigation/Area Navigation
RVSM	Required Vertical Separation Minimum
SATCOM	Satellite Voice and Data Communications
SMA	Surface Movement Advisor
STARS	Standard Terminal Automation Replacement System
SUA	Special Use Airspace
TFM	Traffic Flow Management
TFM-ART	Traffic Flow Management-Architecture and Requirements Team

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## Contents

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TIS	Traffic Information Service
TIS-B	Traffic Information Service-Broadcast
TMA	Traffic Management Advisor
TRACON	Terminal Radar Approach Control
URET	User Request Evaluation Tool
WAAS	Wide Area Augmentation System



# Implementation of Free Flight Represents a Shift From Air Traffic Control to Collaborative Air Traffic Management

The Federal Aviation Administration's (FAA) mission is to promote the safe, efficient, and expeditious flow of air traffic in the U.S. airspace system, commonly referred to as the National Airspace System (NAS). To accomplish its mission, FAA provides services 24 hours a day, 365 days a year, through its air traffic control (ATC) system—the principal component of the NAS.<sup>6</sup> Predicted growth in air traffic and aging equipment led FAA to initiate a multibillion-dollar modernization effort in 1981 to increase the safety, capacity, and efficiency of the system. However, over the past 17 years, FAA's modernization program has experienced substantial cost overruns, lengthy schedule delays, and significant performance shortfalls. Consequently, many of the benefits anticipated from the modernization program—new facilities, equipment, and procedures—have not been realized, and the efficiency of air traffic control operations has been limited. In addition, the expected growth in air traffic will place added strains on the system's capacity.

To get the modernization effort back on track and thereby address the limitations of the present system and meet the growing demand for increasing its capacity, FAA—in consultation with the aviation community—is developing plans to implement a phased approach to modernization, including a new concept of air traffic management known as “free flight.” To enable free flight, FAA intends to introduce a host of new technologies and procedures that will allow the agency to gradually move from its present system of air traffic control, which relies heavily on rules, procedures, and tight control over aircraft operations, to a more collaborative system of air traffic management. Under such a system, users would have more flexibility to select optimal flight paths, whose use would lower costs, improve safety, and help accommodate future growth in air traffic through the more efficient use of airspace and airport resources. Implementing this new air traffic management system will require FAA to introduce new technologies<sup>7</sup> and procedures. FAA plans to

<sup>6</sup>The ATC system comprises a vast network of radars; automated data processing, navigation, and communication equipment; and air traffic control facilities. It is through the ATC system that FAA controls takeoffs and landings and manages the flow of traffic between airports. Other components of the NAS include airports or landing areas; aeronautical charts, information, and services; rules, regulations, and procedures; technical information; and personnel and material.

<sup>7</sup>Many of these technologies, such as the User Request Evaluation Tool (conflict probe) and Single Center Traffic Management Advisor and Passive Final Approach Spacing Tool (traffic sequencing tools) are currently in various stages of development.

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test other new technologies and procedures through an initiative called Flight 2000 (now the Free Flight Operational Enhancement Program).<sup>8</sup>

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## National Airspace System/Air Traffic Control System

FAA's air traffic controllers direct aircraft through the NAS. Automated information-processing and display, communication, navigation, surveillance, and weather equipment allow air traffic controllers to see the location of aircraft, aircraft flight plans, and prevailing weather conditions, as well as to communicate with pilots. FAA controllers are primarily located in three types of facilities: air traffic control towers, terminal area facilities, and en route centers. The functions of each type of facility are described below.

- Airport towers control the flow of aircraft—before landing, on the ground, and after take-off—within 5 nautical miles of the airport and up to 3,000 feet above the airport. A combination of technological and visual surveillance is used by air traffic controllers to direct departures and approaches, as well as to communicate instructions and weather-related information to pilots.
- Terminal area facilities—known as Terminal Radar Approach Control (TRACON) facilities—sequence and separate aircraft as they approach and leave busy airports, beginning about 5 nautical miles and extending to about 50 nautical miles from the airport and up to 10,000 feet above the ground.
- Air Route Traffic Control Centers (ARTCC)—or en route centers—control planes in transit over the continental United States and during approaches to some airports. Planes are controlled through regions of airspace by en route centers responsible for the regions. Control is passed from one en route center to another as a plane moves across a region until it reaches TRACON airspace. Most of the en route centers' controlled airspace extends above 18,000 feet for commercial aircraft. En route centers also handle lower altitudes when dealing directly with a tower or after agreeing with a terminal facility. Aircraft over the ocean are handled by en route centers in Oakland and New York. Beyond the radars' sight, controllers must rely on periodic radio communications through a third party—Aeronautical Radio Incorporated (ARINC), a private organization funded by the airlines and FAA to operate radio stations—to determine aircraft locations.

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<sup>8</sup>Among other capabilities, this demonstration will use (1) the Flight Information Service to provide enhanced weather information and the status of Special Use Airspace, (2) Automatic Dependent Surveillance-Broadcast in a number of ways to improve the efficiency of ground and air operations, and (3) the Traffic Information Service to improve pilots' awareness of surrounding traffic and the efficiency of operations in low-visibility conditions.

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**Chapter 1**  
**Implementation of Free Flight Represents a**  
**Shift From Air Traffic Control to**  
**Collaborative Air Traffic Management**

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- Flight Service Stations provide weather and flight plan services, primarily for general aviation pilots.<sup>9</sup>

See figure 1.1 for a visual summary of air traffic control over the continental United States and oceans.

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<sup>9</sup>Our report focuses on free flight technologies that will be implemented primarily in the tower, terminal, and en route environments. Therefore, we do not include further discussion of Flight Service Stations.